monitored with Calypso (Varian) for gating and tracking treatments, and compensated with the PerfectPitch couch (Varian) for tracking. The dose in the moving tumor was measured with Gafchromic EBT2 (ISP) films. Changes in homogeneity indices (ΔH1-99) between the films and the planned dose distributions and their gamma agreement scores using 3%/3mm (GS3%/3mm) were evaluated. The film areas receiving more than the planned minimum dose (A>Dmin) were calculated. OAR doses from the treatment plans were compared.

**Results:** The results for each MMT are summarized in Table 1, giving the median values with 25% and 75% percentiles over the five measurements with different respiration patterns. All techniques achieved a good coverage of the tumor. Median values for A>Dmin were above 99% for all techniques and ITV and MidV concepts showed lower gamma agreement scores (median: 88.9% and 87.7%) compared to gating and tracking (94.2% and 94.8%). For ITV and MidV concepts larger increases in inhomogeneity were found (median: 4.3 and 5.6 percentage points respectively) than for gating and tracking (2.8 and 2.3). Gating and tracking were able to reduce OAR dose in all cases, when compared to ITV concept.

Table 1: Evaluated parameters from film measurements inside the tumor and planned OAR dose parameters

| | $GS_{3\%/3mm}$ (%) | $\Delta H_{1-99}$ (pp) | $A_{>Dmin}$ (%) | Lung $D_{mean}$ (Gy) | Lung $V_{20Gy}$ (%) | Heart $D_{mean}$ (Gy) | Spinal cord $D_{max}$ (Gy) |
|---|---|---|---|---|---|---|---|
| ITV | 88.9 (82.3-95.7) [97.9] | 4.3 (3.5-5.9) [5.1] | 99.8 (99.6-99.9) [99.5] | 8.3 (7.9-8.9) | 14.1 (13.0-15.5) | 1.4 (1.3-1.5) | 11.1 (10.9-11.7) |
| MidV | 87.7 (74.5-91.5) [97.0] | 5.6 (3.9-7.5) [2.1] | 99.1 (96.9-99.5) [100] | 7.9 (7.2-8.0) | 12.8 (11.3-13.4) | 1.1 (1.1-1.3) | 10.4 (10.2-10.4) |
| Gating | 94.2 (93.2-96.4) [96.5] | 2.8 (2.3-4.2) [1.6] | 99.9 (99.4-99.9) [99.0] | 7.2 (7.1-7.3) | 11.6 (11.3-11.8) | 0.8 (0.6-0.9) | 10.2 (9.5-10.8) |
| Tracking | 94.8 (91.7-96.0) [96.7] | 2.3 (1.1-2.8) [1.8] | 100 (99.9-100) [99.8] | 7.2 (7.2-7.2) | 12.1 (11.9-12.2) | 1.0 (1.0-1.1) | 9.8 (9.7-9.8) |

Values: Median ($q_{25}$-$q_{75}$), [static measurement], pp: percentage points

**Conclusion:** Tracking and gating showed a superior agreement with the planned dose distribution and at the same time reduced the dose to OAR in comparison to the passive motion management techniques.

## EP-1749

## Real-time 4D ultrasound tracking of liver and kidney targets for external-beam radiotherapy

D.S.K. Sihono[1], J. Boda-Heggemann[1], L. Vogel[1], S. Kegel[1], J. Thölking[1], F. Lohr[1], F. Wenz[1], H. Wertz[1]

[1]*University Medical Center Mannheim- University of Heidelberg, Department of Radiation Oncology, Mannheim, Germany*

**Purpose or Objective:** Hypofractionated SBRT is an effective low-toxic therapy option for liver metastases. In our department, liver SBRT is performed in DIBH with ABC (Active Breathing coordinator) and image-guidance with breath-hold CBCT. For additional monitoring of the movable target and/or surrogate structures, an ultrasound-based tracking system has been developed. We evaluated the feasibility and the accuracy of this system on a motion phantom and healthy volunteers.

**Material and Methods:** The tracking accuracy of a 4D ultrasound system (Clarity Anticosti, Elekta, Sweden) was evaluated using an ultrasound phantom (BAT, Nomos) and a motion platform (CIRS, USA) with different settings to obtain optimal parameters to track structures moving with respiration. An initial evaluation was performed with 5 healthy volunteers to assess the performance in a quasi-clinical setting. An ultrasound dataset was acquired in ABC-based breath hold (breath hold time 20 sec, free breathing phases of 5-6 breathing cycles). Tracked structures were renal pelvis as a centroid structure and a portal vein/liver vein as a non-centroid structure. The scanning range of the ultrasound probe was varied. The motion component in superior-inferior direction was compared with the motion of an external marker on the body surface and the data from ABC.

**Results:** a) Phantom data: The tracking accuracy increased with decreasing scanning range. For a cycle time (sinusoidal motion) of 10 s and an amplitude of 10 mm, the mean and standard deviation of differences between the measured and the reference position values were 0.57 + 0.48 mm and 0.31 + 0.20 mm in 15° and 5° scanning range respectively,while for a cycle time of 5 s were 1.33 + 1.20 mm and 0.34 + 0.25 mm for 8° and 4° scanning range respectively. For a fixed scanning range, the accuracy of ultrasound tracking decreased with a decrease of cycle times.

b) Volunteer data: The system's tracking success rate was 90.77% of all breath-hold phases.The renal pelvis tracking success rate was 95.42%, while 86.79% for portal vein.A compromise between scanning range and cycle times had to be established depending on target. A working scanning range was between 10°-40°. For angles <10°there is a higher risk that the target is sometimes outside the ultrasound. This will lead to a reduced tracking success rate. Tracking curves (SI direction)were in good accordance with breathing curves of ABC and a fiducial placed on the infradiaphragmatic abdominal wall.

**Conclusion:** The ultrasound system showed good performance on a motion phantom and healthy volunteers. A positioning setup that provides good ultrasound visual over a long period in clinical environment could be established. Further improvement of the tracking algorithm could improve accuracy along with respiratory motion if using large scanning angles for detection of high-amplitude motion and non-linear transformations of the tracking target.

## EP-1750

## Monitoring of intra-fraction prostate motion with a new 4D ultrasound device

M. Fargier-Voiron[1], P. Pommier[2], S. Rit[1], D. Sarrut[1], M.C. Biston[2]

[1]*Université de Lyon- CREATIS, Physics, Lyon, France*

[2]*Centre Léon Bérard, Physics, Lyon, France*

**Purpose or Objective:** The emergence of hypofractionated protocols in prostate cancer treatment requires a better accuracy in dose delivery because of an increased risk of toxicity to the safe tissues. The aim of this study was to evaluate intrafraction motions of the target volumes for prostate cancer patients imaged with a new transperineal ultrasound (TP-US) device.

**Material and Methods:** The accuracy of the tracking of the TP-US (Clarity®, Elekta, Stockholm, Sweden) probe was first investigated by comparing the measured positions of a target volume in a phantom with the Clarity device and the simultaneous use of a transmitter based positioning device (RayPilot, Micropos Medical, Sweden). Then intra-fraction motions measured with the TP-US were analyzed for 13 prostate patients (426 sessions) and 14 post-prostatectomy patients (438 sessions). The fraction of time that the target volume was displaced by more than 3 and 5 mm was calculated for tracking times ranging between 60-420s, for each session and each patient. The mean displacements were also calculated for each direction. Percentages of sessions for which thresholds of 3 mm and 5 mm were exceeded during 15 s and 30 s in each direction were determined.

**Results:** Differences between TP-US and transmitter based devices were below 1.5 mm for all directions. The observed motions were patients and sessions dependent and increased with the treatment time. During the first minute, 3D displacements above 3 mm were seen 5% and 1.9% of the time, for prostate and post-prostatectomy patients, respectively while they reached 38% and 10.8% of the time after 7 min of treatment. Maximum 3D displacements above 5 mm were observed after 7 min 11.6% and 1.6% of the time for prostate and post-prostatectomy patients, respectively. Mean displacements in AP, SI and LR directions were -0.9±0.8mm, 0.9±0.8mm and -0.3±0.5mm for prostate patients and -0.9±0.5mm, 0.2±0.4mm and 0.1±0.4mm for post-prostatectomy patients. The maximum percentage of sessions for which the prostate and post-prostatectomy volumes exceeded the 3 mm tracking limits for at least 15 s was observed in the AP direction (Table 1). Conversely, minimum